with a feathery coagulum. When the tube was moved, the coagulum separated from wall of the tube and settled to the bottom, leaving the solution in the tube perfectly clear. Further exposure of 20 hours produced only one or two scarcely visible masses of coagulum in the clear solution above the coagulum at the bottom of the tube. The solution contained, however, an abundance of albumin which could be coagulated by heat.

4. *Experiments with Ox-serum.*—The serum was prepared by allowing a clot to form and then decanting off the clear liquid. A portion of this was placed in a quartz test tube and exposed to the light at room temperature. As in the other cases a coagulum formed in the quartz tube while none formed in the glass tube which was exposed at the same time.

The coagulum produced by the light in egg-white and egg-albumin is insoluble in alcohol, hot or cold water and dilute acids. It is soluble in dilute alkalies. In these respects it agrees with the ordinary coagulum which is produced by heat without exposure to ultra-violet light.

W. T. BOVIE
LABORATORY OF PLANT PHYSIOLOGY,
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ASTRONOMICAL AND ASTROPHYSICAL SOCIETY OF AMERICA

THE fourteenth meeting of this society was held at the Allegheny Observatory and the Schenley Hotel, Pittsburgh, from Tuesday to Friday, August 27–31, 1912. Sessions were held at the Observatory on Tuesday and Wednesday, the afternoon of Wednesday being occupied by the exercises of dedication of the new observatory. On Thursday and Friday sessions were held at the Schenley Hotel. An excursion to the Homestead Steel Plant of the Carnegie Steel Company, and a visit to the Carnegie Institute added much to the pleasure of the meeting.

The following members were in attendance: A. T. G. Apple, R. H. Baker, L. A. Bauer, B. Boss, J. A. Brashear, Miss Annie J. Cannon, G. C. Comstock, Z. Daniel, H. S. Davis, A. E. Douglass, W. S. Eichelberger, Philip Fox, Edgar Frisby, Miss Caroline Furness, William Gaertner, Miss A. M. Harwood, F. C. Jordan, T. A. Lawes, F. B. Littell, R. J. McDiarmid, J. B. McDowell, D. B. Marsh, J. A. Miller, O. L. Petitdidier, E. C. Pickering, J. S. Plaskett, A. W. Quimby, H. Raymond, E. D. Roe, Jr., H. B. Rumrill, F. Schlesinger, W. L. Scaife, H. Shapley, A. N. Skinner, F. Slocum, Elliott Smith, C. E. St. John, DeLisle Stewart, R. M. Stewart, Miss Helen M. Swartz, S. D. Thaw, Miss Stella May Udick, C. E. VanOrstrand, Miss Sarah F. Whiting.

Visiting astronomers: Louise S. Smith, A. van Maanen.

The following new members were elected: Miss Stella May Udick, Messrs. Harry Raymond, James Hartness, Arthur Newton, Henry G. Gale, David Rines, E. S. Haynes, William L. Scaife, James B. McDowell.

The constitution of the society was amended to provide for the election of honorary members. In accordance with the provisions of the amendment, nominations were received. Sir David Gill was unanimously elected the first honorary member of the society.

The council voted to hold no meeting in the summer of 1913, because of the probable absence of a number of the members in attendance at the Solar Union meeting at Bonn. The next meeting will be in Cleveland during the holidays, 1912, in connection with the American Association for the Advancement of Science. The council voted to hold the 1914 summer meeting at Northwestern University and the 1915 meeting in San Francisco and at the Lick Observatory.

Officers were elected:

President—E. C. Pickering.
First Vice-president—G. C. Comstock.
Second Vice-president—Frank Schlesinger.
Secretary—Philip Fox.
Treasurer—Miss Annie J. Cannon.
Councillors 1912–1914—W. W. Campbell, E. B. Frost.

The councillors who continue to serve are:

Councillors 1911–1913—W. S. Eichelberger, J. S. Plaskett.

Abstracts of the committee reports and forty-six papers which were read follow:

Irregularities in Atmospheric Refraction: FRANK SCHLESINGER.

This investigation was suggested by the recent work of Nusl and Fric at Prague, who found evidence of irregularities in refraction in a period that is roughly one minute, and having considerable amplitude. At the present author's request Professor Slocum, of the Yerkes Observatory, kindly secured with the 40-inch refractor a number

of plates showing trails of the Pleiades. These plates were exposed on several different nights. Proper precautions were taken to leave the telescope as undisturbed as possible. The trails were measured at the Allegheny Observatory by setting the micrometer wire on the mean position of successive portions of the trail, each corresponding to an interval of about three seconds of time. It was found that on each evening the trails conclusively show the presence of irregular refractions, portions of the trails remaining on one side (of the mean position for that plate) sometimes nearly a minute. On two of the plates simultaneous trails of Alcyone and Merope were measured and these show a remarkable parallelism. The result of this experiment tends strongly to confirm the deductions of Nusl and Fric.

The Orbit of R Canis Majoris: FRANK C. JORDAN.

This star, one of the few Algol variables with an advanced type spectrum, *F*, was discovered to be a light variable, by Sawyer in 1887, and to have variable radial velocity, by Frost in 1905. Forty-nine plates have been obtained at Allegheny in five seasons of observation. The light period has been very accurately determined and is taken as the definitive orbital period.

The elements are as follows: $P = 1.13595$ days; $e = 0.138$; $\omega = 195°.86$; $K = 28.64$ km.; $\gamma = -43.45$ km.; $T = 1908$, Jan. 25.296, Light Minimum; $a \sin i = 453{,}500$ km.; $m'^3/(m + m')^2 = 0.00288 \odot$.

Accurate photometric observations combined with the orbital elements, and the fact that the spectrum is much like that of our sun, will give an independent means of finding the star's parallax.

New Eclipsing Variable Stars: JOEL STEBBINS.

It is probable that a considerable number of the short-period spectroscopic binaries are eclipsing variable stars, and the writer reports progress on tests of these systems with the selenium photometer. It seems practically certain that α Virginis and α Coronæ Borealis are such variables, and β Scorpii is suspected. The first, Spica, has a period of 4.014 days, and shows two minima, a primary of something greater than 0.10 mag., and a secondary of about 0.08 mag. The main eclipse of α Coronæ was observed only once, but it was a decrease of at least 0.12 mag., and came at the predicted time. This star is a member of the extended Ursa Major group, and has a period of 17.36 days. The suspicions of the variation of β Scorpii seem well founded, but need confirmation.

The results emphasize the urgent need of further tests on similar stars.

The Scale of the Durchmusterung: E. C. PICKERING.

The number of stars in the Bonn Durchmusterung is about 460,000; in the Cordoba, 490,000; in the Cape, 450,000; total, 1,400,000, or, omitting duplicates, 1,100,000 stars. In the *Harvard Annals*, **23**, the deviations, from the photometric scales, of the magnitudes 9.0 and brighter are discussed. Volumes **70** and **74** permit a similar study of the fainter stars and of those in the Cordoba Durchmusterung whose average brightness differs as much as a magnitude in different hours, the brightness increasing as the number of stars per degree increases. The photometric magnitude of Bonn 9.5 is 10.5; of Cordoba 10 it is 12.0 in zones $-22°$ to $-42°$, and 11.7 in zones $-43°$ to $-52°$. Stars of a given Durchmusterung magnitude are half a magnitude brighter in zones $-43°$ to $-52°$ than those in the zones $-22°$ to $-42°$.

The deviations of the Cape Durchmusterung magnitudes from the photometric magnitudes are reduced one half by grouping stars on the same plate and applying a correction for the class of spectrum. The average deviation in a provisional reduction of 12 plates is only ± 0.2 mag.

The Progress of the Revised Draper Catalogue: ANNIE J. CANNON.

The purpose of this catalogue is to give the class of spectrum of all stars down to about the eighth magnitude, distributed over the entire sky. Photographs having exposures of sixty minutes have been made at Cambridge and Arequipa with a prism of small angle placed before the objective of 8-inch doublets, and all stars will be classified which are bright enough to be seen clearly and have not already been published in *H. A.*, **28**, and *H. A.*, **56**, 4 and 5. Besides the classification the catalogue will give the photographic magnitude, the identification in some position catalogue, and the place for 1900. The catalogue was started in October, 1911. With an hour's observation each day, about 5,000 spectra can be classified in a month. This rate has been maintained since February, 1912, so that at the beginning of August, 45,000 stars have been classified. Charts were exhibited showing that about one third of the sky has been covered.

A Design for a New Form of Spectrograph Collimator: PHILIP FOX.

This form was proposed for use with the small

quartz spectrograph of the Yerkes Observatory. As the spectrograph was to be used with the 2-foot reflector, of which the angular aperture is $f/4$, the collimator should also have such ratio. The form proposed is in all essentials a small reflector of the cassegrain form. The light coming through the slit falls on the perforated concave mirror, which throws the light upon a small perforated convex mirror, mounted just back of the slit. This second mirror is of such curvature that it throws a parallel beam through the perforation of the first mirror upon the prism. The ratio of perforation to aperture in both cases is equal to the ratio of aperture of the objective of the telescope to the diagonal mirror, and the aperture of the convex mirror is equal to the perforation of the concave, so there is no loss of light. The perforation of the convex mirror centered behind the slit is of sufficient size to permit the use of a slit one eighth of an inch long.

Systematic Motions of the Stars: BENJAMIN BOSS.

Diagrams representing the distribution of stars of the different spectral types and down to the 6.5 magnitude were exhibited. The striking preference of the *B* type stars for the plane of the galaxy, the similar, though somewhat less pronounced, preference of the *A* type for the same plane, and the more random distribution of the more advanced types was clearly shown. We must either conclude that eventually a state of approximately random motion must prevail, or that the later type stars originated uniformly over the entire sky, rather than selecting the plane of the galaxy. The facts revealed by the study of the motions of the stars indicate that the first view is the correct one (*A. J.*, 635–636). The early type stars show a decided crowding toward certain portions of the galaxy, toward the vertices of preferential motion, as discovered by Kapteyn, and toward the apex and antapex of a group of stars called Group IV., or the antapex group, discovered by the writer (*A. J.*, 635). That the motion of this group is in the direction of the antapex of solar motion, and that there seems to be a tendency of motion in the opposite direction, may indicate the existence of a solar group. The analysis of the motions within these groups is now in process of development by the writer.

Observations of Variable Stars at the Vassar College Observatory: CAROLINE E. FURNESS.

Observations of variable stars were begun at this observatory in 1901. The telescopes in use had apertures of twelve, five and three inches. A photographic wedge photometer which could be attached to the twelve-inch was in use for part of the time, but for the most part the comparisons were made by the Argelander method. The observing list included chiefly long-period variables which were selected so that they might pass through a maximum or minimum during the time of observation. The predictions were usually taken from Hartwig's ephemeris. The standard of magnitude was the Harvard photometry, other sources being reduced to this scale.

The resulting observations, about five thousand in number, with a full discussion of the curves and periods of the stars so far as they may be determined, are to be published as soon as their revision is complete.[1]

On the Cause of the Earth's Magnetic Field: L. A. BAUER.

The communication is confined to a consideration of the portion of the field which is symmetrical about both the axis of rotation and the equator. If the intensity of the magnetization be computed for each parallel of latitude over the region best covered by magnetic observations, 60° N. to 60° S., on the basis that the average values of the observed magnetic components along a parallel correspond to those of a uniform magnetization parallel to the axis of rotation, then a systematic and regular increase in the intensity is observed in both hemispheres with approach to the equator. This may be stated mathematically thus: If X be the magnetic component along a true meridian, positive toward the north, and Z be the vertical component, positive downward, then for the field, symmetrical as stated, the components, for any co-latitude u, will be

$$X = f_x(u) \sin u \quad \text{and} \quad Z = f_z(u) \cos u.$$

These "characteristic functions" show an increase of 13 to 17 per cent. from the parallel of 60° to the equator.

None of the theories thus far advanced to account for the origin of the earth's magnetic field gives the law of the observed increase in the characteristic functions. With but few exceptions, the attempts have been restricted to ascertaining a cause for a uniform magnetization. Since this course has not led to generally accepted results, it was decided to begin with the geographical variations, hoping that, if their cause be determined, valuable clues might be found as to the origin of the primary field. Thus a closed physical expres-

[1] See *Popular Astronomy*, **20**, 645, 1912.

sion was found, consisting of the zonal harmonics of the first and third order, which represents the facts to within one per cent.

Supposing the bound electrical charges in each atom of the earth to be separated by some cause into positive and negative atomic charges an infinitesimal distance apart, such that the total charge throughout the earth of each kind of electricity be equal and the volume density of each charge vary from parallel to parallel as $\sin^2 u$; then, by reason of the earth's rotation, a magnetic field results whose potential is the expression mentioned in the preceding paragraph. The first term corresponds to a uniform magnetization of the earth parallel to its axis of rotation having about one tenth of the strength of the total portion assignable to a uniform field; the second term, consisting of the third order harmonic, reproduces satisfactorily the observed increase in the characteristic functions. If it be assumed that the separating agency is the component of the earth's centrifugal force acting in the direction of the radius away from the center, a distribution of the two opposite electricities throughout the earth would apparently result, following, as a first approximation, the same law of density, supposed in deriving the expression, the zonal harmonics. Before a final statement, however, can be made as to the precise cause, a more complete examination will have to be made and full consideration be given to all the various effects involved.

Radial Motion in Sun-spots: C. E. ST. JOHN.

The results obtained to date indicate the following mean conditions:

Element	Line	Intensity	Direction	Vel. in Km. per Sec.
Ca	H, K		Inward	2.5
H	Hα		Inward	1.4
Na	D		Inward	0.2
Mg	b		Inward	0.3
Al	λ 3961	20	Inward	0.1
Fe	Mean of several near λ 5200	6	Outward	0.40
Fe		5	Outward	0.43
Fe		4	Outward	0.52
Fe		3	Outward	0.61
Fe		2	Outward	0.66
Fe		1	Outward	0.75
Fe		0	Outward	0.84

Results similar to those of iron appear for other metallic vapors producing lines of moderate intensities, though the velocities from lines of equal intensities for different elements are not equal. This offers a means of determining the relative levels at which lines of different intensities have their origin, in terms of some standard such as iron.

Three regions are indicated in the solar atmosphere surrounding spots with the following characteristics at the different levels: (1) The upper chromosphere, motion inward, shown by the H and K lines of calcium and H_a of hydrogen; (2) an intermediate region shown by the D lines of sodium, b lines of magnesium, and the strong aluminum and iron lines, motion inward generally prevailing; (3) a lower region of outward motion, velocity increasing with lower levels, on the assumption that when considered by and large the weaker lines are associated with the lower levels.

Pressure in the Solar Atmosphere: C. E. ST. JOHN.

In the new spectrograph of the 150-foot tower telescope the sources of error associated with the instability of the apparatus, the illumination of the grating and the centering of the solar image, have been overcome, the first, by the massive construction of the spectrograph, the head of which weighs about 4,500 lbs.; the second, by the larger diameter, 15 inches, of the cone of sunlight incident upon the grating which the long focus, 75 feet, of the spectrograph permits when the 12-inch objective of 60-feet focus is used to form the solar image on the slit; the third, by fixing the slit rigorously on the axis of the centering circles. The error introduced from non-centering of the image may be large; with the image now used (diameter 162 mm.) the solar lines would be shifted 0.001 Å. by solar rotation when the slit is 2 mm. from the center of the image and on small images the error might be much greater.

With this equipment an investigation involving a comparison of the arc and solar spectra of iron is being carried out. The preliminary results show that the solar lines of iron classified in accordance with their displacement in solar spectrum fall into the classes suggested by Gale and Adams in their study of pressure shift under laboratory conditions and indicate pressures in the solar atmosphere varying from 0.7 to 6.5 terrestrial atmospheres for the different groups.

On the Diurnal Variations of Atmospheric Pressure: W. J. HUMPHREYS.

It has been known for nearly two and a half centuries that there are more or less regular daily variations in the height of the barometer, culminating in two maxima and two minima during the course of the 24 hours; the maxima occurring

at 10 o'clock, roughly, forenoon and evening, the minima at 4 o'clock, roughly, afternoon and morning.

All that is needed, apparently, to give the semi-diurnal pressure curve, is a pressure impulse of the same period, 12 hours, as that of the free vibration of the atmosphere as a whole. And this, it seems, is furnished by a forced forenoon barometric maximum, due to the interference of vertical convection with the free flow of the air, followed, six hours later, at the same place by a forced afternoon barometric minimum, caused by expansion and overflow. In other words, taken together the forenoon and afternoon forced disturbances appear to occur with the proper time interval necessary to set up and maintain the 12-hour free vibrations of the atmosphere.

The course of events at each locality, affecting the height of the barometer, appears to be substantially as follows: (1) A forced forenoon compression of the atmosphere followed by its equally forced afternoon expansion; both due to a single heating and the two together forming one complete barometric wave, with a 10-o'clock maximum and a 4-o'clock minimum, in harmony with the free vibration of the entire atmosphere shell. (2) Non-disturbance through the night, or during the period of a single free vibration. (3) Repetition the following day of the forced disturbances in synchronism with, and therefore at such time as to reinforce, the free vibrations. The series of disturbances of course is indefinitely great, alternately forced and alternately free, but the resulting amplitudes of the barometric changes are limited, through friction and through the absence of perfect synchronism, to comparatively small values.

A Screen for Equalizing Star Magnitudes for Transit Circle Work: F. B. LITTELL.

The equalizing screen consists of two sets of thin brass slats at right angles to each other, intermeshed to form a rectangular, honeycomb structure. The slats are 1/2 inch wide, 1/120 inch thick and 1/5 inch apart, and make an angle of 45° to the plane of the meridian. The whole is mounted about 3 inches in front of the objective and may be tilted about an axis parallel to the horizon, the operation being effected and the amount read at the eye end. The light which falls on the objective is evenly distributed in nearly rhombic areas. A tilt of 30° gives total extinction. The bright spectral images formed by the bright stars which vary in character with the setting of the screen can be rendered practically invisible in a bright field by preliminarily reducing the light by means of one or both of the two wire mesh screens which have been used on the instrument for several years and which are retained for this purpose.

24-inch Objective of the Sproul Telescope: J. A. MILLER and R. W. MARIOTT.

The 24-inch objective for the Sproul telescope by the John A. Brashear Co. was completed and mounted in the Sproul Observatory of Swarthmore College in December of 1911. This paper discussed the quality of this objective as determined by the Hartmann method. In February of 1912, extra focal exposures on Capella were made through a screen containing 44 circular holes, 33 mm. in diameter, so arranged as to cover 9 zones of the lens. The exposures were made on Cramer Instantaneous Isochromatic plates. A yellow ray filter made by Wallace in accordance with the color curve of the objective was placed in front of the plate and almost in contact with it. Later a set of extra focal exposures were made on Arcturus in the same way. In the meantime, however, a spring holding the lens in its place in the cell was slightly loosened. The exposures on Arcturus were through a screen containing 78 circular holes of 25 mm. diameter, so arranged that it covered 10 zones. The measure demonstrated that qualitatively the two tests showed slight axial stigmatism, at approximately the same points in the lens. Hartmann's characteristic *T* for the Arcturus test is 0.270 and for the Capella test, 0.274, showing that the lens is an excellent one.

The Orbits of 44 Eclipsing Binaries: HARLOW SHAPLEY.

Using the methods recently developed by Professor Russell, orbits have been computed for all eclipsing variable stars for which there exists reliable photometric data. Included in the material discussed are unpublished observations made by the writer with the Princeton polarizing photometer of the stars *RZ* Draconis, *RX* Draconis, *RR* Draconis, *WZ* Cygni, *AE* Cygni, *ZZ* Cygni, *RW* Capricorni, *RX* Herculis and *RW* Monocerotis. The periods of a few stars have been redetermined. Secondary minima have been found from an analysis of maximum light observations in the cases of *U* Cephei, *R* Canis Majoris, *RZ* Draconis, *ST* Carinæ, *SU* Centauri and *SZ* Centauri, and possibly for *S* Cancri, δ Libræ and *RW* Monocerotis. The investigation of the light curves of

U Ophiuchi, *RZ* Centauri and *SZ* Centauri shows that the periods of these variables are double the values heretofore given, for in each case two minima of unequal depth alternate. This is also probably true for *SS* Carinæ and for *RX* Draconis.

For more than 80 per cent. of the orbits studied circular elements represent the observations satisfactorily. In no instance has an orbital eccentricity been found to exceed 0.1. The fainter component is very generally the larger of the pair. In only one case out of nine is the dark companion definitely smaller. Pairs of equally luminous stars are rare; equal radii are more common.

The elongations of the component stars through gravitational interaction has affected the shape of the light curves for one third of the number here considered to a degree sufficient to be taken into account in the discussion of the orbits. The square of the eccentricity of a meridian section of the assumed similar prolate spheroids is greater than 0.30 for β Lyræ, *RS* Sculptoris, *RR* Centauri and *V* Puppis; it is greater than 0.20 and less than 0.30 for *U* Pegasi, *U* Scuti and *u* Herculis; and between 0.10 and 0.20 for *U*. Ophiuchi, *V* Serpentis, *RZ* Centauri and *SZ* Centauri. These data have enabled the comparison of the *observed* relation between the prolateness and distance of centers with the *theoretical* relation derived by Darwin for equal masses of homogeneous, incompressible fluid. A remarkable agreement is found.

The densities of the pairs were computed in terms of the sun's density, on the assumption of equally massive components. An important relation is found connecting density and spectral type. The average density of nine stars of Classes *B*1 to *B*8 is 0.16; of 26 stars of Class *A* it is 0.13; but for eight stars of Classes *A*5 to *F* the average is 0.55. No star of the first two groups has a density as great as one half that of the sun; and the solar density is not exceeded by any in the third group.

A general investigation has been made in connection with Professor Russell of the theory of darkening at the limb in eclipsing variables and of the relation existing between orbital elements derived on the assumption of uniformly illuminated disks and of disks darkened to zero at the limb. Tables analogous to those used in deriving elements on the former assumption have been constructed.

On the Graphical Representation of Eclipsing Variables: Henry Norris Russell.

The computed elements of an eclipsing variable are admirably adapted for graphical illustration. A diagram of the system as seen from the earth exhibits at a glance all the geometrical elements. By a proper choice of scale, it may be made to show much more. If we assume that each component is equal in mass to the sun, their mean distance (in solar radii) will be 5.29 $P^{2/3}$, where P is the period in days. If platted on this scale, the radius of the orbit will at once indicate the period, and those of the individual stars their probable densities (on the usual assumption of equality of mass). By suitable shadings, the relative surface brightness may also be indicated, and thus practically all the facts for several systems may be displayed on a single sheet.

Such diagrams also give, in all probability, a very good idea of the actual dimensions of the various systems. No stellar system has yet been reliably investigated whose mass is less than one fourth that of the sun; and masses exceeding sixteen times the sun's are very rare. It follows that the actual dimensions of a given system, compared with the sun, are very unlikely to be more than twice, or less than half, those indicated by diagrams prepared as above. Since most eclipsing variables are too faint for direct spectrographic investigation, this is probably the best way at present available of getting an idea of their real size.

Relation Between Spectrum and Color-index of 500 Stars: J. A. Parkhurst.

The revised data from the writer's forthcoming catalogue of magnitudes and spectra of northern stars[2] furnishes material for a curve showing the relation between spectrum and color-index. The range in magnitude of the stars used is between 4 and 9, the greater number lying between 6 and 8.5. The average magnitude is 7.3 visual, corresponding to 7.7 photographic since the color-index of the average star is 0.4. The Harvard classification is used.

Platting the color-index as abscissæ and the spectral class as ordinates, a straight line is found to fit the points better than any simple curve. The lantern slide accompanying the paper shows a comparison between this "curve" and those published by King in *Harvard Annals*, **59**, 180, and Schwarzschild in his Göttingen *Aktinometrie*, *B*, 19. King's stars are mostly brighter than magnitude 4.5, while Schwarzschild's are about the same brightness as those measured by the writer. The present work differs from the other

[2] *Ap. J.*, **36**, 169, 1912.

two, in that all elements used were determined by the same person and the same instrument.

The Attraction of Sun-spots for Prominences: FREDERICK SLOCUM.

In the autumn of 1910 a large group of sun-spots passed several times across the face of the sun. On its first passage, from August 2 to August 15, it was given the Greenwich number 6,874.

Active prominences were observed in the immediate vicinity of the spot group from August 2 to November 5, but the best displays occurred on the west limb on October 8, extending from Lat. + 6° to — 37°, and on the east limb on October 22, extending from Lat. + 12° to — 36°. Slides of calcium spectroheliograms of the spot, the surrounding flocculi and the attendant prominences were shown.

The prominences were pouring from both sides apparently right down into the spot. Points that can be identified on two or more plates give velocities along the apparent trajectory up to 110 km. per second, and show a marked acceleration towards the spot. The conclusion is that some sun-spots exert an attraction for the material of which prominences are composed.

No.	Star	π	P. E.	Remarks
1	ϕ Androm.	+0.″014	±0.″017	Visual binary.
2	48 Cassiop.	—0.001	±0.015	Visual binary.
3	20 Persei	—0.008	±0.006	Visual binary.
4	9 Camelop.	+0.030	±0.005	Spectroscopic binary.
5	μ Orionis	+0.036	±0.007	Spectroscopic binary.
6	Groningen VII. 20	+0.129	±0.012	Faint star with large proper motion.
7	*BD* 18°, 3424	+0.004	±0.014	Faint star with large proper motion.
8	17 Lyræ *C*	+0.128	±0.008	Faint star with large proper motion.
9	*P* Cygni	—0.014	±0.008	Nova?
10	τ Cygni	+0.001	±0.007	Visual and spectroscopic binary
11	Nova Lacertæ	+0.011	±0.013	Nova.

Stellar Parallaxes from Plates made with the Forty-inch Refractor of the Yerkes Observatory: F. SLOCUM and S. A. MITCHELL.

The present parallax program contains about 150 fields, including (*a*) stars with large proper motion, (*b*) stars with large radial velocity, (*c*) binaries, visual and spectroscopic, (*d*) selected stars of the different spectral types, (*e*) novæ, and stars in any way peculiar, (*f*) the Kapteyn zone + 45°. The following parallaxes have recently been determined:

The average number of plates used for each of the above determinations is eleven, the average number of comparison stars, five, and the average magnitude of the comparison stars, 9.6. Numbers 3, 4, 5, 9 and 10 were measured and reduced by Professor S. A. Mitchell, of Columbia University, and numbers 1, 2, 6, 8, 11 by Professor Slocum, and number 7 by Miss M. M. Hopkins, of Smith College.

The Spectrum of Nova Geminorum No. 2 on March 13, 1912: R. H. CURTISS.

The Detroit Observatory slit spectrograms of Nova Geminorum II. secured on March 13, 1912, show characteristics which have important bearing on the nature of the spectral changes of a nova as it approaches its maximum radiance. The nova's spectrum on this date strongly resembles that of March 15, when the nova maximum type was generally recognized, the peculiarities of the light on the earlier date being strongly accentuated two days later. The conclusion is suggested that the peculiarities of the nova type appeared in the spectrum of this star earlier than has been supposed.

The Plane Grating Spectrograph for Stellar Work: J. S. PLASKETT.

This paper gives a short account of some preliminary tests on the use of a plane grating as the dispersion piece of a stellar spectrograph. The grating with ruled surface 2⅞ by 3¾ inches, 15,000 lines to the inch, was specially ruled to give great concentration and it is estimated that 50 per cent. of the incident light is diffracted into the first order on one side. The spectrograph has been tested only in the Littrow form, with a 2½-inch Brashear Triplet of 37½-inch focus, giving a linear dispersion of about 17.5 Å. per mm. at H_γ. It gives beautiful definition and a field very nearly flat over the range used from λ4800 to λ3500. The relative intensity of star spectra obtained with this instrument, and the Ottawa three-prism spectrograph with a camera objective giving the same dispersion at H is as follows: Region λ4700–λ4300, prismatic about twice as intense as diffraction spectrum. Region λ4300–λ4200, spectra of nearly equal intensity. Region λ4150–λ4100, diffraction two to three times as intense

as prismatic spectrum. Region λ4100–λ3850, diffraction spectrum of nearly uniform intensity and nearly as strong as at H_γ. Prismatic spectrum, none. It is evident that with this dispersion the diffraction spectrograph is superior, especially towards the violet and ultraviolet. When it is compared with a single prism spectrograph of lower dispersion the advantage will likely be the other way, but if a spectrum of uniform intensity over a wide range is required, and in the red end, where the prismatic spectrum is unduly compressed, the grating spectrograph will undoubtedly possess many advantages. As soon as possible a more complete test of its performance will be made.

The Cincinnati Astronomical Society: DELISLE STEWART.

This paper describes the organization and activities and plans of the society. The suggestion is made that some definite connection between the national and local societies might be worth consideration.

Radium and the Chromosphere: S. A. MITCHELL.

This paper has been published in *A. N.*, 4600, so only the conclusions need be given here.

At the 1905 eclipse, while a member of the U. S. Naval Observatory expedition in Spain, the writer photographed the "Flash Spectrum" with such dispersion and definition that it permitted the determination of wave-lengths which are in error but a few hundredths of an Ångstrom. A comparison with the radium spectrum showed that a majority of the lines due to radium nearly coincide in the chromosphere with lines already satisfactorily identified from other sources. The third strongest line of radium at λ4826.10, if present in the chromosphere, must be very weak. The comparison between the spectra of radium and of radium emanation and the chromosphere has led me to the conclusion that there are no radium lines in the sun. A similar lack of uranium lines likewise appears.

It will be necessary to obtain photographs of novæ with a much greater dispersion than that used at Bonn before deciding that radium or uranium lines are found in their spectra.

Absorbing Medium in Space: EDWARD S. KING.

The results given in *Harvard Annals*, **59**, indicated the presence of an absorbing medium in space. The amount found was 0.0377 mag. for the photographic rays, and 0.0184 mag. for the visual rays, while traversing the unit of distance, which is measured by 32.6 light-years.

These figures having been derived from 26 stars, it was thought best to improve the data by applying the method to other stars. Accordingly, a supplementary list of 22 stars was prepared from the *Publications of the Groningen Laboratory*, No. 24, and observed. The procedure was in all respects precisely that followed previously. The resulting values had the same sign, indicating absorption by greater redness, but were somewhat larger than before. By selecting from both lists only those stars having the parallax most accurately determined, the reduction gave values identical with the above results from *Harvard Annals*, **59**. Thus, the indications from this work also point to the presence of an absorbing medium in space, or some factor which produces effects similar to absorption by making the more distant stars appear redder.

Proper Motions of Faint Stars: GEORGE C. COMSTOCK.

The writer, who has been engaged for some years upon a study of the motions of the faintest stars for whose determination adequate material can be found, presents in this paper results relating to more than 250 stars fainter than the tenth magnitude of the Harvard scale. These motions have been derived from micrometer observations by which the positions of the faint stars are referred to neighboring brighter ones of known proper motion, the time interval covered by the measures being in a few cases as small as a quarter century but more frequently extending to fifty or seventy-five years. The probable error of the motion assigned each star in each coordinate has been determined, and from a comparison of these numbers with similar data given in Boss's Preliminary General Catalogue it appears that the proper motions here considered, tenth to thirteenth stellar magnitude, are at least of equal precision with those given for the fainter stars of the Boss Catalogue, 7.5 to 9.0 magnitude. The proper motions here considered are all referred to the Boss system.

In a certain number of cases the motions here investigated are shown to be orbital, the faint star being physically connected with its brighter companion; but when the angular distance separating the stars exceeds the Struve double-star limit of 32″ this connection is found to be very infrequent and in about 80 per cent. of the cases here investigated, *i. e.*, more than 200 stars, the motion of the faint star appears to be uninfluenced by its

brighter companion. Frequency curves showing the distribution of total proper motion and of motion in both right ascension and declination were exhibited and certain suggestions relative to the structure of the stellar system were derived from them; *e. g.*, the mean motion of these stars, about 3″.5 per century, is larger than has usually been supposed, indicating a smaller total extent than is commonly attributed to the sidereal universe. A general southerly drift, shown by these stars, suggests that in great part they lie outside a group associated with the sun and comprising a large part of the brighter stars. The precession constant furnished by these faint stars is shown to be in excellent agreement with that found by Boss from the brighter stars, implying that these bright stars possess, as a whole, no motion of rotation about the earth's axis that is not shared by the fainter stars.

A curious empirical relation, long known but little heeded, is confirmed and considerably extended by these results, viz., the product, stellar magnitude multiplied by proper motion, is approximately constant over all magnitudes from the second to the eleventh, inclusive, and unless there are conditions of the problem not now apparent this relation would imply that in the average of a large number of cases a star's distance from the sun is proportional to its numerical magnitude. This suggestion is probably of too revolutionary character to be readily accepted, although it is paralleled by the conclusion reached by Campbell from spectroscopic evidence that the stars of different magnitudes are more thoroughly intermixed in space than has been commonly assumed.

The Solar Eclipse of April 16, 1912, as Predicted and as Observed: ARTHUR NEWTON.

The Nautical Almanac Office is preparing for the press the final installment of Professor Simon Newcomb's "Researches on the Motion of the Moon." Corrections therein given have been applied in the American Ephemeris and Nautical Almanac for 1912 to the moon's position in the computation of the two solar eclipses of the present year.

The many observations made on April 17 are entirely confirmatory of the accuracy of these final values by Professor Newcomb. The American Almanac gave a predicted time of occurrence that was within two seconds of the mean observed time. The European almanacs were in error from 15 to 30 seconds. The central line of eclipse was placed about one mile too far to the northwest by the American Almanac, and much farther in the same direction by the other almanacs, with the exception of the French.

These results indicate that the moon's position as employed in the American Ephemeris for this eclipse required a further correction of + 1″.0 to the longitude and of — 0″.5 to the latitude. The prediction was further borne out in the phase which was total in Portugal and Spain with a maximum duration of one second, and annular in France with a duration of three or four seconds at Paris. The indicated correction to the adopted semi-diameter of the moon is less than 0″.2.

A Method of Approximating Rainfall over Long Periods and Some Results of its Application: A. E. DOUGLASS.

It was found by a test extending over 43 years that the radial thickness of the rings of the yellow pine of northern Arizona gives a measure of the rainfall in that vicinity with an average accuracy of over 70 per cent. By applying a simple formula, taking into account the conservation of moisture, the accuracy may be increased to about 75 per cent. By cross identification of rings between all the hundred trees examined, the accuracy of counting rings was greatly increased.

Five trees from the vicinity of Flagstaff were measured to the number of 400 rings, and two of these to 500. It was found that all the trees in that locality gave very similar records. A 21-year variation amounting in all to 20 per cent. of the mean is shown in 400 out of the 500 years recorded. A shorter variation amounting to 16 per cent. of the mean was found to have a period of 11.4 years. Its plot derived from 492 years shows 2 maxima which correspond in time with 2 maxima of rainfall in the 50 years of records on the southern California coast. These in turn match the major and minor maxima in the temperature of that region for the same period. The larger maximum of the latter occurs at the time of the sun-spot minimum as averaged for 125 years.

The Algol Variable RR Draconis: F. H. SEARES.

The writer made an attempt to determine the light curve of this star from observations with the 7½-inch refractor of the Laws Observatory. On account of its faintness it could not be followed through the minimum. On August 7 the star was followed photographically through an eclipse with the 60-inch reflector of the Mt. Wilson Observatory. Sixty-five exposures, covering an interval of 6 hours, were obtained. The variable is normally of 9.70 mag. There is an interval of

constant minimum brightness, lasting about $1\frac{1}{2}$ hours, during which the magnitude is 13.50. The duration of eclipse is $8\frac{1}{2}$ hours. The light change is very rapid, the last magnitude of the descent is accomplished in 20 minutes. For two magnitudes of the descent the visual and photographic curves are in close agreement, but from this point the photographic variation seems more rapid than the visual. For $\Delta m = 3.25$ mags. visually, the photographic value is 3.50. This greater photographic range is probably real. The observed time of minimum was eleven minutes late of the ephemeris from the elements of the Laws Observatory Bulletin No. 9, indicating a correction to the period, which is slightly less than $2^d\ 20^h$, of less than a second.

Spectrographic Observations of ϕ Persei: FRANK C. JORDAN.

This star has been known, since 1889, to have a bright line spectrum. About 400 spectrum plates have been obtained by various observers, and its period determined as 126.5 days. The hydrogen lines are constituted as follows: A broad, weak, underlying absorption, upon which is superposed a broad emission line appearing as two because of a central narrow and strong absorption. The sharpness and strength of the absorption lines varies strikingly in different parts of the orbit, becoming at one phase so weak and diffuse as to be almost immeasurable. Helium lines show only at certain phases. There are visible at least twelve other bright lines which seem to be constituted like the hydrogen lines, and to give the same velocity as these lines.

The velocity curve is peculiar in that at about one third of the period from maximum positive velocity there is a decided hump. The highest velocity is + 44 km. It goes down to — 7 km. at phase 24 days, up to 0 km. at phase 35 days, then down to a minimum of — 21 km. at phase 75 days. In different revolutions of the system the velocity curves do not seem to be the same either in shape or amplitude.

Preliminary measures on the bright hydrogen lines give a velocity curve different from that of the absorption lines, but not such a curve as would be given by a secondary body.

Spectrographic Observations of Algol: FRANK SCHLESINGER.

Algol has been upon the observing list for the Mellon spectrograph during the past six years. A total of 336 spectrograms have been secured, and have been measured and reduced by the author under as uniform conditions as possible. A study of this material yields the following chief results: (1) The long period oscillation in the radial velocities, announced by Belopolsky in 1906, is unmistakably confirmed. This oscillation has a period of 1.874 years and a semi-amplitude of 9.14 km., and is in an orbit whose eccentricity is small. (2) Such an oscillation should be accompanied by a similar oscillation in the times of light minimum, the latter sometimes occurring as much as 5 minutes in advance and sometimes 5 minutes after the predicted epochs. An examination of the rich photometric material on this star obtained in the years from 1852 to 1887 brings out this small term with almost precisely the amplitude computed from the spectrographic measures. (3) The eccentricity of the short-period orbit (2.87 days) comes out small, very probably less than 0.02. This seems to make it necessary to reject Tisserand's explanation for Chandler's long-period term (141 years) in the times at which light minima occur, since this explanation demands an eccentricity in the neighborhood of 0.13. A renewal of photometric observations of Algol is much to be desired, as well as a rediscussion of all the available data of this kind.

The Orbit of λ Tauri: FRANK SCHLESINGER.

Eighty-nine spectrograms of this bright Algol variable have been secured with the Mellon spectrograph at the Allegheny Observatory. These yield the following elements of its orbit: period (assumed from photometric data), 3.9529 days; semi-amplitude 58.1 km. $\pm$ 1.08 km.; eccentricity, 0.053 ± 0.017; longitude of periastron, $111°.6 \pm 20°.5$; time of periastron passage, 0.31 days after light minimum $\pm$ 0.23 days; mean velocity, + 13.6 km.

The lines in the spectrum of this star are affected by shadings alternately on their red and violet sides. These can not be due to the presence of the fainter spectrum, since they are too close to the lines of the bright spectrum to permit of this explanation. The spectrograms are all upon plates of fine grain.

The Magnitude Scale of the Polar Sequence: F. H. SEARES.

The methods of photographic photometry employed with the 60-inch reflector of the Mt. Wilson Observatory involve the use of a wire gauze screen and diaphragms of various apertures. The most troublesome difficulty has been the determination of the error depending on the distance of the stars from the axis of the instrument which varied

from plate to plate and with direction on the same plate. The erratic variations seem now to be eliminated. At present, the point of greatest interest in photographic photometry relates to the determination of an absolute scale. The first determination of magnitudes has been for stars of the polar sequence. Fifteen plates with the wire gauze screen and diaphragms of 32 and 14 inches, affording 27 separate determinations of the scale, have been used. The exposures range from 1 to 11 minutes, the magnitudes from 8.8 to 17.6, although the limits for reliable results are 10.5 to 15.5. The mean deviations of groups of stars from results obtained at the Harvard Observatory are as follows:

Magnitude	Mt. W.-H.	No. Stars
8.81	+ 0.11	1
10.5 — 11.5	— 0.03	6
11.5 — 12.5	— 0.02	4
12.5 — 13.5	+ 0.03	6
13.5 — 14.5	+ 0.03	5
14.5 — 15.5	— 0.01	5
15.5 — 16.5	— 0.13	4
16.5 — 17.5	— 0.27	7

The zero point of the Mt. Wilson scale is such that the sum of the deviations from the Harvard scale between 10.5 and 15.5 is zero. The cause for the divergence beyond mag. 15.5 is not yet established, but may be settled by comparing the scale here given with that derived from plates of longer exposure.

Variable Asteroids: S. I. BAILEY.

In connection with the photometric measurements of Eros, made at Arequipa in the years 1902 and 1903, observations of Ceres, Parthenope, Massalia, Kalliope, Urania, Harmonia, Melete, Hecuba, Sirona, Baucis, Celuta, Chryseis, Kallisto, Kleopatra, Germania, Bamberga, Tercidina, Melusina, Ilmator, Aquitania, Aurelia, Eros and Tergeste, were undertaken especially for the detection of new cases of variability in light. The Rumford photometer was used with the 13-inch Boyden telescope. Five cases of variability, in addition to Eros, were detected: Urania (30); indications of variability, no satisfactory period found. Hecuba (108); indications of a small range of variation, having a period which appears to be a sub-multiple of $0^d.99$, perhaps $0^d.330$. Sirona (116); indication of range of half a magnitude with period $0^d.403$. Celuta (186); variation small, if real, period $0^d.364$ satisfies all observations. Tercidina (345); small variation, satisfied with period $0^d.366$.

The light curves of Eros independently determined by the Rumford photometer and by photographs made with the Bruce telescope agree closely, but those obtained with the photographs have the smaller accidental errors. The photographic method offers many advantages. In order that photographs shall serve for the accurate determination of magnitudes, it is very desirable that the images of the asteroids shall be comparable with those of the stars. This can be accomplished by giving to the plate, while the telescope is moving at sidereal rate, a motion equal to one half the apparent motion of the asteroid.

Results of Latitude Observations at the Flower Observatory from December, 1904, to July, 1911: C. L. DOOLITTLE.

The series here considered consists of 13,852 determinations of latitude made with the zenith telescope, and 11,591 with the Wharton reflex zenith tube. All of the observations were made by myself and the two series are practically simultaneous. A comparison of the results given by the two instruments furnishes data, to be found nowhere else, so far as I know, for examining the daily fluctuations to be found in all extended series of this character.

For this purpose we have 1,540 comparisons. We find 149 cases where the residuals from both series are at least twice the probable error. Of these, 79 have like signs and 50 unlike. There are 12 cases where both residuals are at least three times the probable error; 10 of these have like signs. In these cases the residuals are four times the probable error and in one case six times the probable error. All of these have like signs.

It is obvious that we have to do with a class of errors other than those due to observations, and that before much greater progress can be hoped for in this direction, means must be found for this elimination.[3]

The Constant of Aberration: C. L. DOOLITTLE.

From the observations carried on at the Sayre and Flower Observatories from December 1, 1889, to June 8, 1911, with the zenith telescope and the reflex zenith tube there have been derived 22 values of this constant. Although these range in value from $20''.448$ to $20''.605$, the computed value of the probable error in no case differs very much from $0''.01$. If we give all equal weight we have

[3] See *A. J.*, 641.

for the arithmetical mean of all, $20''.526 \pm 0''.0057$. There are, however, very good reasons for assigning higher weights to some of the 22 values than to others. The results have been derived from observations at two different places with practically four different instruments. We find, however, for the weighted means practically the same value as that given above, $20''.525 \pm 0''.0045$. The corresponding value of the solar parallax is $8''.780$.[4]

A Test of the 18½-inch Objective of the Dearborn Observatory Telescope: PHILIP FOX.

It has been interesting to apply Hartmann's test to this objective, the high quality of which is established by the long series of difficult double-stars which have been discovered with its aid by both Burnham and Hough. The perforated screen contained 96 holes, 12 mm. in diameter, arranged on 24 zones. The resulting curve of zonal foci is very smooth. The extreme range in focal length for the different zones is about 2 mm. The mean of the two sets gives for the Hartmann criterion T, the result $T = 0.30$.

Some Results from the Personal Equation Apparatus of the 9-inch Transit Circle of the U. S. Naval Observatory: W. S. EICHELBERGER and F. B. LITTELL.

With a personal equation apparatus the following results were obtained for the three observers, L, M, P, positive corrections indicating that the observer anticipates.

CHRONOGRAPHIC OBSERVATIONS

δ	Sec δ	L RL	L LR	M RL	M LR	P RL	P LR
		s	s	s	s	s	s
0°	1.0	−0.132	....	−0.038	....	−0.060	....
39	1.3	−0.131	−0.136	−0.028	−0 038	−0.077	−0.100
62	2.1	−0.130	−0.167	−0.018	−0.045	−0 057	−0 112
82	7.4	−0.120	−0.188	−0.033	−0.058	−0 129	−0.153
85.1	11.7	−0.115	−0.203	−0.021	−0.037	−0.062	−0.112

EYE AND EAR OBSERVATIONS

δ	Sec δ	L RL	L LR	M RL	M LR	P RL	P LR
85.1	11.7	+0.29	+0.23	+0.02	+0.05	+0.18	+0.23
87.7	24.9	+0.39	+0.29	−0.04	+0.18	+0.25	+0.27
88.9	52.1	+0.78	+0.64	+0.15	+0.26	+0.55	+0.68

Assuming that the personal equation can be represented by $p + m \sec \delta \pm n \sec \delta$, the coefficients were computed and corrections applied, thus reducing the errors to a very small quantity, generally less than $0^s.01$ for chronographic, and less than $0^s.05$ for eye and ear observations.

[4] See *A. J.*, 639, and Pub. Flower Observatory, Vol. III., 2.

Comparisons were made to test the reliability of these results, with satisfactory consequence.

A High-level Measurement of Solar Radiation: FRANK W. VERY.

Applying the methods elaborated in a previous paper, "The Violle Actinometer as an Instrument of Precision,"[5] to the reduction of an observation by M. Violle, who obtained from a sounding-balloon record at an altitude of 13,700 m. an excess of 53° in sunshine above an air temperature of 65° below zero Centigrade, the author obtained for the observed solar radiation-equivalent at 13,700 m., 2.86 gram cal./sq. cm. min. Making allowance for the absorbent atmosphere, deriving the value from the consideration of observations at sea-level, Keeler's and Nanry's on Mt. Whitney, Violle's on Mt. Blanc, the value of the solar constant obtained is 3.5 gram cal./sq. cm. min.

A Criterion of Accuracy in Measurements of Atmospheric Transmission of Solar Radiation: F. W. VERY.

The coefficient of atmospheric transmission of solar radiation on a given day is variable because of the variation of atmospheric extinction with zenith distance, and because this absorbent quality changes in the middle of the day, especially if much moisture is present. Thus in Bouguer's formula,

$$R = Ap^{\epsilon},$$

there are two variables p and ϵ, and the equation is soluble only by approximation.

To accomplish this approximation, M. Crova has proposed that the curve of radiation shall be considered as the envelope of a series of logarithmic arcs. By constructing successive subtangents to this envelope at points having values of ϵ for abscissæ, coefficients of transmission of the sifted rays, at stages corresponding to determined values of ϵ, can be found by the equation

$$T = e^{-\frac{1}{m(1+\epsilon)}},$$

where

$$m = \log\left(\frac{1+\epsilon_1}{1+\epsilon_2}\right) \div \log\left(\frac{R_2}{R_1}\right).$$

This procedure usually gives a series of varying values of m, so that a solution of the problem is no nearer, unless some occasion can be found when m does not vary appreciably. Such an extraordinary occasion is on record in the observation by Savélief at Kief, Russia, December 28,

[5] *Pub. A. A. S. A.*, **2**, 90.

1890, which may be used as a test by which less perfect measurements may be judged. By theory, we have the criterion that $1/m$ must always be a fraction. Rejecting all observations which do not conform to this criterion, also midday observations which are affected by the usual midday depression, the author compares the mean of the two series of observations by Kimball with Savélief's measures. The mean values are:

$$\epsilon = 7, \text{ Savélief } 1/m = 0.647,$$
$$\text{Kimball } 1/m = 0.786;$$
$$A = (1 + 7)^{0.647} \times 0.94 = 3.606 \text{ (Savélief)};$$
$$A = (1 + 7)^{0.787} \times 0.72 = 3.698 \text{ (Kimball)}.$$

Application of the criterion brings these otherwise discordant observations into agreement.

Sky Radiation and the Isothermal Layer: F. W. VERY.

The author describes the mechanism of heat transference and radiation absorption in the atmosphere, referring to his work on "Atmospheric Radiation," pp. 114–115 and 124. Vapors are found in the atmosphere just so long as there remains a quantity of even the least absorbing gases sufficient to preserve the temperature above the vaporization point. It was pointed out in discussing the absorbing power of gases and vapors that the absorbing power of some gases was so feeble that many miles of absorbing layers were necessary to show the spectrum lines, while other lines, notably those of water vapor, are produced by the substances in very attenuated form. Water vapor is found at the altitude of 30 km., and since temperature inversion in the atmosphere is found everywhere associated with excessive amounts of aqueous vapor, there is no reason to doubt that the great region of permanent temperature inversion, the "isothermal layer," is due to this substance. The extreme tenuity of the vapor offers no difficulty to this supposition, since the layer is many kilometers deep. I have found the great Xi bands of aqueous vapor producing almost complete extinction of the solar spectrum through a range of 3 microns, when the temperature was $-30°$ C. This temperature is sometimes exceeded even in the isothermal layer, where also a relative humidity as high as 50 per cent. has been observed.

There are three principal loci of terrestrial radiation, namely: (1) a thin, heated, superficial layer of the terraqueous globe; (2) the solid or liquid particles suspended in the air; and (3) the upper static layer of air, called the isothermal layer, in which the permanent temperature-inversion resides. The author's supposition that elevated regions of the atmospheric, up to something like 20 km., undergo much larger temperature-variations than the more deeply situated layers of the free air, has been confirmed by Blair's observations. This phenomenon also is attributed principally to absorption by aqueous vapors.

The earth's effective temperature is not that of an elevated layer of cool air, shown on the records of the meteorological stations, but a mean in varying proportions of the three loci named, which owe their temperature to a complex of radiation, convection, absorption, cloud precipitation, etc.

The general conclusion from sky measurements is that the effective sky-temperature is lower, on the whole, when the dew-point is lower, and the aqueous obstruction of radiation to space is least; but even in the coldest and driest weather, the sky temperature has never been found lower than that of the isothermal layer, which behaves like a nearly black body of approximate temperature, $T = 218°$ Abs. C., λ max $= 13.5\,\mu$, and is opaque to most of the radiation from the solid earth of greater wave-length than this maximum.

Orbits of the Visual and Spectroscopic Binary Star Epsilon Hydræ AB: R. G. AITKEN.

The close double star known as ϵ Hydræ *AB*, discovered by Schiaparelli in 1888, is unique among the visual binary systems in that the elements of its orbit can also be deduced from the spectrographic measures of the radial velocity.

A revised system of elements from the micrometer measures, which now cover an arc of 450°, gives 15.3 years as the best value for the revolution period. Adopting this as correct, the remaining elements were computed independently from the radial velocity measures, which extend from 1899 to 1911 and include both maximum and minimum values. It was possible to find a set of elements which would satisfy both series of observations within the error of observation. These elements are: $P = 15.3$ years $= 5{,}588$ days; $T = 1900.97 =$ J.D., 2,415,375; $e = 0.65$; $\omega = 90°.0$; $i = -49°.95$; $\Omega = 104°.4$; $a = 0''.23$; $a \sin i = 493{,}000{,}000$ km.; $v = +36.78$ km.; $K = 8.45$.

From these elements we find the mean distance between the two components of ϵ Hydræ to be 1,359,000,000 km., or 9.1 astronomical units, the parallax of the system, $0''.025$ and its mass, 3.33 times the sun's mass. Seeliger has shown that the periodic variations in the micrometer measures connecting the third star C with the close pair

can be accounted for by the orbital motion of the binary. Assuming the effective light center of AB to be one seventh of the distance from A toward B, he determines the mass ratio of the binary to be $m'/m = 0.9$.

Within the next five years the radial velocity will again reach both maximum and minimum values, and spectrographic observation during this interval will be of the greatest value in determining the orbit elements more precisely.

International Standards of Wave-lengths: C. E. ST. JOHN and L. W. WARE.

This paper, which has appeared in full in the Contributions from the Mount Wilson Solar Observatory, No. 61, gives the results of the measurements of two series of plates of the iron arc spectrum, obtained with two plane grating spectrographs, one on Mt. Wilson and one in Pasadena. The precision obtained by interpolation between the international standards of the second order is 0.001 Ångstrom in the case of good lines. No errors were found in the relative wave-lengths of the secondary standards between λ5371 and λ6494 greater than 0.001 Ångstrom except for the line λ5434, where it is 0.002 Å. In this region 44 lines were found unsuitable for standards of wave-lengths on account of pressure displacements accompanied with dissymmetry. Several lines showed differences in wave-length between the two series, bearing relation to the quality of line under pressure as shown on the plates of Gale and Adams.

The Solar Rotation: J. S. PLASKETT.

This paper presents the general results of a determination of the solar rotation for 1911 and a preliminary result for 1912. The values obtained at Ottawa for 1911 are well represented by the formulæ

$$v = (1.483 + 0.532 \cos^2 \phi) \cos \phi,$$
$$\xi = 10^\circ.32 + 4^\circ.05 \cos \phi,$$

where v is the sidereal linear velocity of the reversing layer in km. per sec., and ξ the daily sidereal angular velocity, ϕ the solar latitude. These are in remarkably good agreement with Duner's and Adams's 1908 values, except for a small angular difference constant for all latitudes. The formulæ probably represent very closely the law of variation with latitude. Measures of the same plates by different observers give systematic differences of two or three per cent., indicating that the differences noted above are probably personal, and due to the character of the lines. The discussion of some 3,000 residuals from different lines and elements show no systematic differences of velocity for different elements, or for different lines of the same element. No change greater than one per cent. is revealed in results for 1911 and 1912.

The Spectroscopic System 9 Camelopardalis: O. J. LEE.

This star was announced as a binary by Frost and Adams[6] from measures of the broad lines. They also found that the H and K lines, strong and narrow, give a variation which differs in phase and amplitude from that given by the other lines.

The observations cover about 3,000 days. The form of the velocity curve is incompatible with a simple two-body system and hence a certain form of calcium envelope has been assumed which both assists in reproducing the observed velocity curve and accounts for the difference in character of the broad lines and the calcium lines in the spectrum. The observed velocity curve is composed of three elements: the orbital velocity of the primary, the velocity of the calcium envelope about the center of the primary regarded as a stationary point, and the periodic eclipse of the spectroscopically effective parts of the envelope by the primary.

The elements of the stellar orbit are: $P = 7.9957$ days, $e = 0.30$, $\mu = 45^\circ.024$, $K = 9.0$, $\omega = 90^\circ$ or 270° closely, $T =$ J.D. 2,416,480.35, $\gamma = -2.25$ km., $i = 90^\circ$ nearly.

Assuming that the effective calcium clouds center about the two zero velocity points, which lie one on each side of the primary $M/m = 2.85$ and $M + m = 0.0023$.

The Rotation of Jupiter's First Satellite: A. E. DOUGLASS.

This satellite appears elliptical in form. A number of persons unacquainted with the identity of the satellites have been asked to select the one appearing elliptical. In fourteen out of seventeen trials the first has been picked out. The ellipticity is not constant, but varies on a period which does not seem to be constant. A hypothesis to account for the phenomena supposes the satellite to be an irregular body resembling an ellipsoid of three unequal axes in which the axis of figure has a considerable angle to the axis of rotation.

The Light-curve of SS Cygni from the Amherst Observations: D. P. TODD and C. J. HUDSON.

Observations of this star and about 50 other

[6] *Ap. J.*, **19**, 350, 1904.

faint variables have, for the past two years, been regularly maintained with the 18-inch Clark refractor of the Amherst College Observatory. The observations are visual estimates and are accurate to tenth-magnitudes. They were much facilitated by the use of an external iris diaphragm, enabling the use of all apertures from 3 to 18 inches. The remarkable fluctuations of this star are represented on a diagram prepared by Mr. Hudson.

REPORTS OF COMMITTEES

Professor Campbell sent a written report from the Committee on Cooperation in the Measurement of Radial Velocities. The response of all the members of the committee was to the effect that though they might wish to cooperate, their instrumental resources were too weak to attack a long list of stars below the 5.0 visual magnitude where cooperation is desirable, and further, that fields of greatest usefulness for them consisted in the study of spectroscopic binaries or special groups of stars. In short, cooperation in the determination of radial velocities of extensive lists of stars fainter than the 5.0 mag. is at present impractical. The report ended with some hopeful suggestions.

The report of the Committee on Asteroids, sent by the chairman, Professor E. W. Brown, stated that the principal problems of those interested in the asteroids is to gather data for future discussion, the orbits, the light variations, etc. The first problem is the collection of the observations of position. Some organization to secure more nearly uniform observation of the many asteroids, to care for the new ones, to make certain the securing of a requisite number of early observations, to furnish an early orbit, should be perfected. An international conference on the asteroid problem is desirable.

The Committee on Comets, Professor G. C. Comstock, chairman, reported that the work of collecting data of photographic observations of Halley's comet was practically complete. The catalogue is ready for publication. The committee proposes to publish this together with the photographs secured by Mr. Ellerman at Honolulu.

Professor Schlesinger presented the report of the Committee on Photographic Astrometry. The 10-inch photographic telescope described in the last report has been mounted and put in operation. It is mounted in a constant temperature room having access to the polar region through a window of optically plane parallel glass. Exposures made from without and automatically timed on the chronograph give very exact data for determining the polar point. The methods developed for measuring and reducing the plates were described and some numerical results presented. This work will be continued at least until the spring of 1913, by which time it is expected that definite knowledge will be secured concerning the movement of the pier mounted in this way.

The financial report showed an indebtedness of about $200. Dr. John A. Brashear announced the purpose of certain Pittsburgh friends of the society to clear this indebtedness. This unprecedented generosity was gratefully acknowledged.

The report of the Committee on Teaching of Elementary Astronomy is of more general interest, so it is given in full.

Report of Committee on Cooperation in Improvement of Teaching Elementary Astronomy: C. L. DOOLITTLE, chairman. Report prepared by Miss Sarah F. Whiting.

Your committee was authorized at the Ottawa meeting to send out a circular to the observatories and colleges asking certain questions in reference to the teaching of elementary astronomy, and requesting suggestions as to methods of increasing the numbers in elementary courses, and improving the teaching.

A circular was sent out with the following preamble, to show the intent of the society:

"The Astronomical and Astrophysical Society of America states in its constitution that its purpose is the 'advancement of astronomy.'

"At its late meeting in Ottawa, Canada, it was mindful of the fact that the advancement of science depends not only on the discovery of new truth, but on the diffusion of knowledge, and the scientific spirit which creates a friendly atmosphere for its reception. The society considered the deplorable ignorance of persons, otherwise intelligent, in regard to the every-day phenomena of the sky, and the fact that astronomy lags behind the other sciences in adopting the modern method of laboratory work by the student."

Questions followed in reference to the beginning courses and methods of teaching.

Eighty replies were received, which may be considered representative, since twenty were from state universities, thirty from other universities and colleges of first rank, and thirty-two from smaller colleges and schools. Only ten reported a beginning course in astronomy extending through the academic year; thirteen reported two terms or a semester's work, and the other forty-two only

short lecture courses. Only thirty reported a regular program of evening observations, twelve some daytime exercises, ten some review of the elements of spectrum analysis as a basis for study of stellar classification, fourteen gave some library work, the rest gave only lectures with no laboratory work by the student. But two institutions, Harvard and Wellesley, reported two hours of daytime laboratory work by the students as in other sciences, and this in addition to evening work.

The numbers in the colleges electing an elementary course would be more significant if they could be reported in percentages, but this was not possible. That only eight universities and colleges reported a hundred and more in the first-year classes, three, 70–100, six, 50–70, and sixty-five mostly less than twenty-five, shows that a very small proportion of college men and women know much about anything off this little planet.

Special interest in the movement was emphatically expressed in more than half the replies, and the hope that the society can in some way bring its influence to bear to secure greater place for elementary astronomy in the programs of study, better methods of teaching elementary classes, and aid the teachers to secure better equipment and adequate assistance.

The leaders of the great research observatories, Harvard, Lick, Yerkes, Mt. Wilson, all expressed sympathy in the objects of the committee and the hope that astronomy would not long lag behind other sciences, taken up in liberal education. Several called attention to the fact that teachers of elementary astronomy should be trained as teachers of physics are trained. Colleges should be urged to understand that an observatory for the training of experts is not the entire equipment necessary for the work of a department of astronomy. Some replies, however, state the issue clearly from the standpoint of the heads of the departments of astronomy. In the choice between using the observatory for instruction or for research, the research problems have the stronger claims. As in other cases, the professor should be provided with adequate assistance.

The committee has brought the facts before the Society and calls for the assistance of the Society in constructive plans. The committee has no plan as yet formulated, but requests that it be continued.

Philip Fox,
Secretary

SOCIETIES AND ACADEMIES

THE NEW ORLEANS ACADEMY OF SCIENCE

On Tuesday, November 12, there was held at the Public Library the first regular meeting of the newly reorganized New Orleans Academy of Science. The New Orleans Academy of Science was founded in the year 1853, and was a vigorous society until the war, when its activities were suspended. It was revived again for a brief period soon after the war and then again in 1885, when it met regularly for about five years and published several volumes of transactions. Since 1890 the academy has been dormant.

As now reorganized it consists of sixteen sections with chairmen for each section as follows:

Biology and Physiology, Gustav Mann.
Botany and Bacteriology, C. W. Duval.
Zoology, George E. Beyer.
Anthropology and Ethnology, R. B. Bean.
Philology, Robert Sharp.
History and Biography, Pierce Butler.
Education, J. M. Gwinn.
Economics and Sociology, A. P. Howard.
Chemistry, Miss Ann Hero.
Geology and Mineralogy, B. V. B. Dixon.
Astronomy and Mathematics, A. B. Dinwiddie.
Geography and Meteorology, J. A. Lyon.
Engineering, W. H. P. Creighton.
Physics, H. Clo.
Philosophy, W. B. Smith.

The officers of the newly organized academy are:

President—William Benjamin Smith, professor of philosophy, Tulane University of Louisiana.

First Vice-president—Dr. Max Heller.

Second Vice-president—Dr. Isadore Dyer, dean of the medical department, Tulane University of Louisiana.

Treasurer—Dr. A. L. Metz, professor of chemistry, Tulane University of Louisiana.

Secretary—R. S. Cocks, professor of botany, Tulane University of Louisiana.

Librarian and Curator—Dr. Creighton Wellman, professor of tropical medicine and hygiene, including preventive medicine, Tulane University of Louisiana.

At the inauguration meeting there were addresses by the president and the two vice-presidents. The academy will meet hereafter the second Tuesday of each month.

R. S. Cocks,
Secretary